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Structural controls and timing of fault-hosted manganese at Woodie Woodie, East Pilbara, Western Australia

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ABSTRACT

High-grade fault-hosted manganese deposits at the Woodie Woodie Mine, East Pilbara, are predominantly hydrothermal in origin with a late supergene overprint. The dominant manganese minerals are pyrolusite, braunite, and cryptomelane. The ore bodies are located on, or near the unconformities between the Neoarchean Carawine Dolomite and the Paleoproterozoic Pinjian Chert breccia (weathering product of Carawine Dolomite), and sedimentary units of the overlying ca 1300–1100 Ma Manganese Group. Stratabound manganese is typically located above or adjacent to steep fault-hosted manganese. The ore bodies range in size from 0.2 to 5.5 Mt with an average of 0.5 Mt. Historically, over 35 Mt of manganese has been mined at Woodie Woodie, and current ore resources are 29.94 Mt at 39.94% Mn, 6.96% Fe (resource and reserves statement, June 2011, Consolidated Minerals Pty Ltd).

Manganese mineralization at Woodie Woodie is related to northwest–southeast directed extension and basin formation during the Mesoproterozoic. Basin architecture is generally well preserved and major manganese occurrences are localised along growth faults which down-throw the Pinjian Chert Breccia into local extensional basins. Manganese ore bodies are typically located on steep 2nd and 3rd order structures that extend off the major growth faults. Mineralized structures display a dominant northeast-trend reflecting the direction of maximum dilation during northwest–southeast extension.

A paragenetic sequence is identified for the manganese ore at Woodie Woodie, with early hydrothermal braunite–pyrolusite–cryptomelane–todorokite–hausmannite, overprinted by late supergene oxides. Preliminary fluid inclusion studies in quartz crystals intergrown with pyrolusite and cryptomelane indicate that primary and pseudosecondary inclusions display a range of salinities from 1 to 18 eq. wt.% NaCl and trapping temperatures estimated to be from 220° to 290° at 1 kbar pressure.

A lead–manganese oxide (coronadite) is common in manganese ores at Woodie Woodie, and Pb-isotope studies of 40 lead-rich ore samples from 16 pits indicate mineralization occurred within an age range of 955–1100 Ma. A mixed source is suggested for the lead, but was predominantly basalts and/or volcanogenic sedimentary units (e.g., Jeerinah Formation) of the ca 2700 Ma Fortescue Group. The typically high Mn:Fe ratios and enrichment in elements such as Pb, As, Cu, Mo, Zn are consistent with a dominantly hydrothermal origin for the manganese at Woodie Woodie. Supergene manganese is distinguished from hypogene manganese by a marked enrichment in REE in the supergene manganese.

An early structural framework, established during Neoarchean rifting, provides a major structural control on manganese ore distribution. The Woodie Woodie mine corridor is located in a zone of oblique strike-slip extension on major northwest-trending transform faults and north-trending oblique normal faults. A major transform structure at the southern end of the Woodie Woodie mine corridor (Jewel-Southwest Fault Zone) likely acted as a major fluid conduit for manganese-bearing hydrothermal fluids and this would account for the concentration of significant manganese ore occurrences to the north and south of this structure.

1. Introduction

The Woodie Woodie manganese operation is operated by Consolidated Minerals Pty Ltd (CML) and is located on Warawagine Station in the East Pilbara District, about 400 km southeast of Port Hedland (red box in Fig. 1). The first published report of the manganese in

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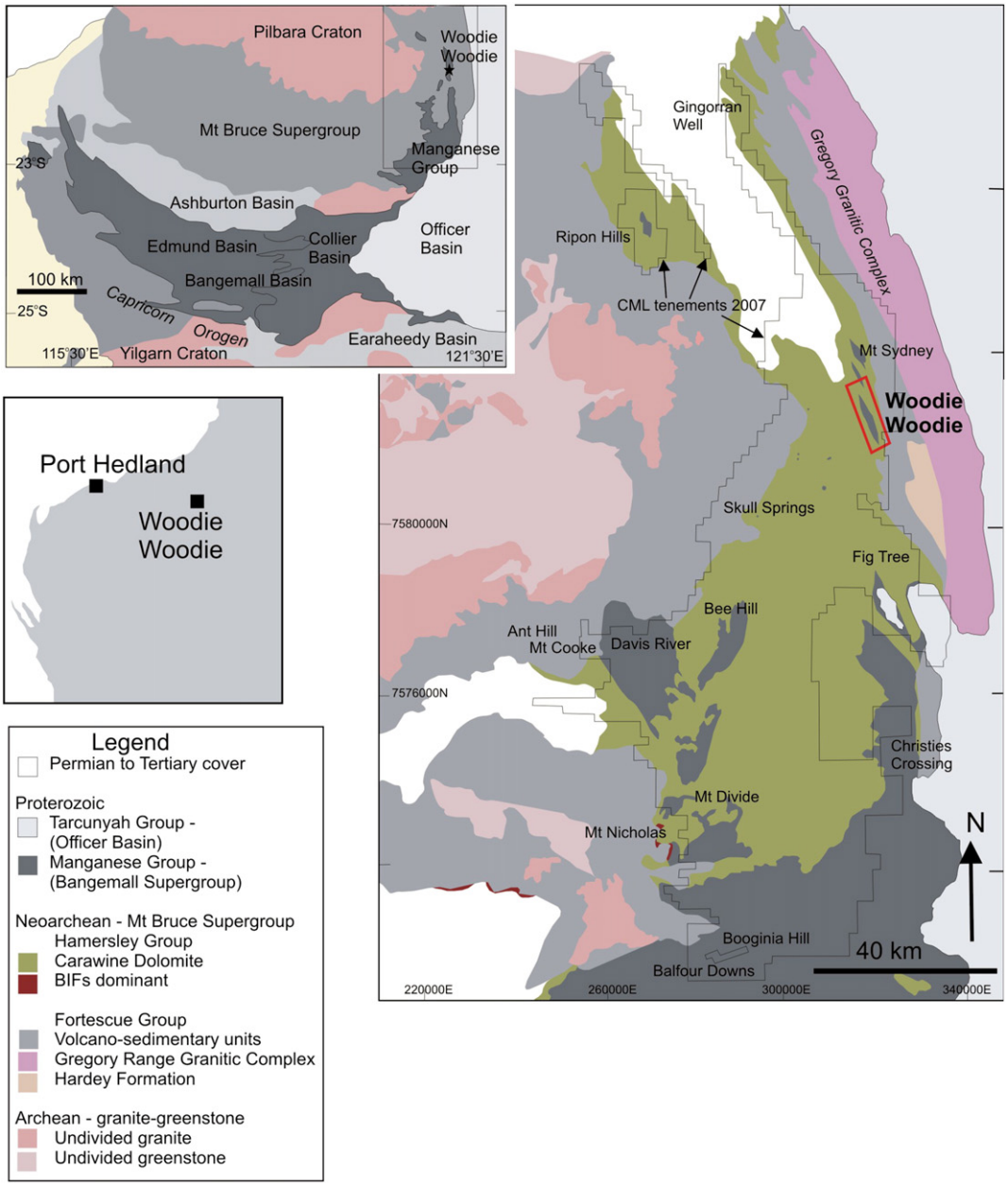

Fig. 1. Tectonic setting of the Woodie Woodie deposits in the Oakover basin, East Pilbara. The outline of CML exploration leases and locality names referred to in the text are indicated. Modified from Geological Survey of Western Australia regional geology and CML mapping (full references provided in Jones, 2011).

the Woodie Woodie mine corridor was in the early 1960s by de la Hunty (1963), but exploration and production of manganese in the Woodie Woodie area has been ongoing since the early 1950s with numerous small mining operations to the south of Woodie Woodie, including Skull Springs, Bee Hill, Davis River, Ant Hill and Sunday Hill (Fig. 1). The Woodie Woodie mine corridor is about 3.5 km wide and extends for ~30 km from the Radio Hill and Whodowe mines in the north to Mike mine in the south (Fig. 2). The operation produces a high grade manganese product with an average grade of Mn 45% and Fe 5%. Historically, over 35 Mt of manganese has been mined at Woodie Woodie, and current ore resources are 29.94Mt at 39.94% Mn, 6.96% Fe (resource and reserves statement, June 2011, Consolidated Minerals Pty Ltd).

The Woodie Woodie mine is located in the Oakover River catchment area in the East Pilbara. In this paper the area is referred to as the Oakover basin, rather than the Oakover Syncline (Hickman, 1978) to avoid a structural reference. The geology of the Oakover basin is dominated by flat-lying to gently dipping ca 2600 Ma Carawine Dolomite of the Hamersley Group (Hickman, 1978; Noldart and Wyatt, 1962; Rasmussen et al., 2005). The Carawine Dolomite is overlain by the Pinjian Chert Breccia that predominantly represents the Paleoproterozoic weathering product of the Carawine Dolomite (de la Hunty, 1963; Jones, 2011; Noldart and Wyatt, 1962). The Carawine Dolomite and Pinjian Chert Breccia are unconformably overlain by sedimentary units of the 1300–1100 Ma Manganese Group, which is a correlative of the Collier Group of the Mesoproterozoic Bangemall Basin (Martin and Thorne, 2004; Williams, 1990). The western side of the Oakover basin is defined by a series of low hills comprising gently east-dipping units of the Fortescue Group (MacLeod et al., 1963), whereas the western side of the basin is defined by the Gregory Range, that has formed along a series of steep north- to north-northwest-trending faults, with steeply dipping units of the Fortescue Group along the